Physics 129: Problem Set #4
Due: Fri Sept 28, 2001 at 5PM
Homework Box available on 2nd Floor LeConte breezeway

Note: The first midterm will be held in class on Wed Oct 3. It will cover material from lectures through Friday Sept 28 and Problem Sets 1 through 4.

This problem set covers material from Perkins Chapter 3. You might also want to look at Griffiths Chapter 4 for another view of the same material.

1. *Noether's Theorm* Suppose a particle interacts according to the Hamiltonian

$$H = p^2/2m + Fz$$

   Use Noether's theorm to determine which of the following are conserved quantities: p_x, p_y, p_z, p^2, L_x, L_y, L_z, L^2. Here p is the particle's momentum and L is its angular momenturm.

2. For each of the following operators, specify whether the operator is a vector, pseduovector, scaler or pseudoscaler:

   (a) $\vec{S}$ the particle's spin

   (b) $\vec{r}$ the particle's position with respect to the origin

   (c) $\vec{p}$ the particle's momentum

   (d) $\vec{L}$ the particle's angular momentum

   (e) $\vec{B}$ the magnetic field in a region of space

   (f) μ the moment of a particle

   (g) $-\mu \cdot B$ the energy of a magnetic moment in a B field

   (h) $(\vec{p_1} \times \vec{p_2}) \cdot \vec{s}$

   (i) $\vec{p_1} \times \vec{p_2} \times \vec{p_3}$

3. The Λ baryon is produced in the process

$$\pi^- + p \rightarrow \Lambda + K^0$$

This is a strong interaction (the Λ has strangeness -1 and the K^0 has strangeness +1 so strangeness is conserved). The Λ has spin $\frac{1}{2}$ so we can define an observable called the polarization $< \vec{S} \cdot \vec{\hat{n}} >$, the expectation value of the component of spin in a specific direction $\hat{n}$. The term "production plane" defines the plane that contains the initial π momentum and the final Λ momentum (momentum conservation tells us there is no component of momentum outside this plane)

   (a) Show that the strong interactions rules out a final state Λ polarization in the production plane. Hint: use the fact that the strong interactions conserve parity.

   (b) Show that a polarization for $\hat{n}$ out of the production plane is permitted.

4. Perkins problem 3.2

5. Perkins problem 3.3

6. Perkins problem 3.5